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WATER QUALITY OF THE LAKE VERNON FAIRY LAKE MARY LAKE WATERWAY (HUNTSVILLE)

1973

Ministry of the Environment
Ontario

WATER QUALITY

OF THE

LAKE VERNON-FAIRY LAKE-MARY LAKE WATERWAY

(HUNTSVILLE)

WATER QUALITY BRANCH
1973

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SUMMARY AND CONCLUSIONS

1. In general, the physical-chemical and biological characteristics of water in the Huntsville area (Lake Vernon to Mary Lake waterway) indicated excellent quality. Information collected from the three lakes (Vernon, Fairy, Mary) provided no evidence of water quality deterioration, even though these lakes are extensively used for recreational purposes and substantial lengths of the shorelines are lined with cottages. However, it must be made clear that the study was designed to provide an over-all assessment of water quality; local shoreline problems, resulting for example from improperly-functioning private waste-disposal systems, would not be detected in this type of general study. It is also possible that the rate of eutrophication is being slightly accelerated by man's activities; however, the long-term rate of change in water quality cannot presently be evaluated due to the absence of historical water quality data.

Existing water quality data, along with the large hypolimnetic volumes, would indicate that Lakes Vernon, Fairy and Mary are not particularly sensitive to cultural eutrophication. Water quality problems are not expected to materialize in these lakes in the near future.

2. The study did provide some evidence of minor alterations in water quality below the effluent from the sewage treatment plant at Huntsville. While sampling frequency was not sufficient to allow for a statistical evaluation of the data, it appears that conductivity values, as well as concentrations of phosphorus (soluble and total), were slightly elevated at station C9, about two-thirds of a mile downstream from the municipal effluent.

Ontario

Ministry of the Environment

135 St. Clair Avenue West
Suite 400
Toronto Ontario
M4V 1P5

December 3, 1973

W.M. Walkinshaw

Dear Sir:

Please find enclosed a copy of the report 'Water Quality of the Lake Vernon, Fairy Lake, Mary Lake Waterway (Huntsville)' which summarizes the results of physical, chemical and biological studies carried out on the Lake Vernon to Mary Lake system.

In general, the survey findings have shown that the waters throughout this important recreational watercourse are of good quality with only slight impairment occurring below the effluent from the Huntsville Water Pollution Control Plant. Slightly elevated concentrations of phosphorus were detected in the vicinity of this discharge, however, it is anticipated that the recently installed nutrient removal facilities at the Huntsville plant have improved this situation.

Should you have any questions or wish to obtain additional copies of the report, please do not hesitate to contact this office.

Yours truly,

John H. Neil

John H. Neil
Director
Water Quality Branch

encl.

Visual observations of periphyton on the artificial substrates provided evidence that the nutrient-rich effluent from the sewage treatment plant was promoting the growth of aquatic plants in the downstream watercourse.

A fairly detailed investigation of the macroinvertebrate life upstream and downstream from the effluent showed that there was no detectible effect on the bottom fauna.

3. The bottom of a large portion of Hunters Bay is blanketed with wood particles as a result of previous logging activities. An investigation of the sediment throughout Hunters Bay revealed that there was no detectible effect of these wood particles on the bottom-invertebrate community.

The exposed piles of wood chips on the shoreline property of Weldwood of Canada Limited, which are slowly being eroded by the water, do not appear to be affecting the chemical or biological quality of the adjacent waters. However, the shoreline piles of chips have transformed a stable, attractive shoreline into an unstable shoreline which is aesthetically unpleasing.

RECOMMENDATIONS

1. Efforts to improve the effluent quality from the sewage treatment plant at Huntsville should continue. Since the collection of the field data which is presented in this report, facilities for phosphorus removal have been installed at the sewage treatment plant and this will help to protect downstream water quality.

2. Weldwood of Canada Limited should investigate the possibilities of restoring the stability and aesthetics of the

shoreline where the piles of wood chips are presently located. Although the wood-chip piles present only a minor problem, the feasibility and economics of restoring the shoreline should be discussed with the Ministry of Environment.

INTRODUCTION

Early in 1970, a water quality survey of the lower part of the East River was initiated in order to obtain pre-operational data in the vicinity of Kimberly-Clark of Canada's new tissue mill which was then under construction. This East River study was completed after having collected the 1971 post-operational data, and a public report has recently been released entitled "Effects Of The Kimberly-Clark Tissue Mill (Huntsville) on Water Quality Of The East River".

In conjunction with the East River survey, the downstream waters of Lake Vernon, the Huntsville River, Fairy Lake, part of the Muskoka River and Mary Lake were investigated during 1970 and 1971. The present report describes water quality in these lakes and connecting rivers.

The Lake Vernon to Mary Lake waterway was investigated for three principal reasons. Firstly, the area constitutes a prime recreational resort and the maintenance of good water quality and identification and correction of developing pollution problems at an early stage is essential. Prior to 1970, water quality data for this area was practically non-existent. Secondly, the Town of Huntsville discharges its treated municipal wastes (0.25 million imperial gallons per day) to the Huntsville River and there is concern about the possible effects of this discharge on the receiving waters. Since the time of this survey, however, phosphorus-removal facilities have been installed at the sewage treatment plant at Huntsville and this has resulted in a higher degree of waste treatment. Thirdly, with the establishment of a major tissue mill only three miles upstream from Lake Vernon, the desirability of obtaining background data for the waters from Lake Vernon to Mary Lake is obvious. However, the 1971 sampling program

on the East River, which included samples from the industry's final effluent, soon revealed that the new Kimberly-Clark plant was having no detectible effect on the East River, much less on waters several miles downstream (Ministry of Environment report -- see Bibliography).

SCOPE OF STUDY

The investigation consisted of physical, chemical and biological measurements that were obtained during the ice-free periods of 1970 and 1971. In 1970, physical-chemical measurements were carried out at only two locations - one located in a deep section of Fairy Lake (station C11, see Figure 1), and the second in a deep section of Mary Lake (station C21). Each of these two locations were sampled on three dates during the summer - twice in July and once in August.

In 1971, physical-chemical characteristics were evaluated at a total of 21 locations throughout the study area (Figure 1); each location was sampled on five occasions (both night and day) during a 72-hour survey from July 20-23. In addition, three of the locations (C1, C11 and C21) were sampled in May, August and September.

Biological sampling was carried out at a total of 21 locations in 1970 and 31 locations in 1971 (Figure 1).

METHODS

A) Physical-Chemical

The physical-chemical evaluation included a large number of parameters that are listed in Appendices I and II. At most of the sampling locations, characteristics of only the surface water were investigated. However, at locations C1, C12 and C21, analyses were conducted both at the surface (i.e. 1 m below surface) and near bottom (see Appendix for specific depths).

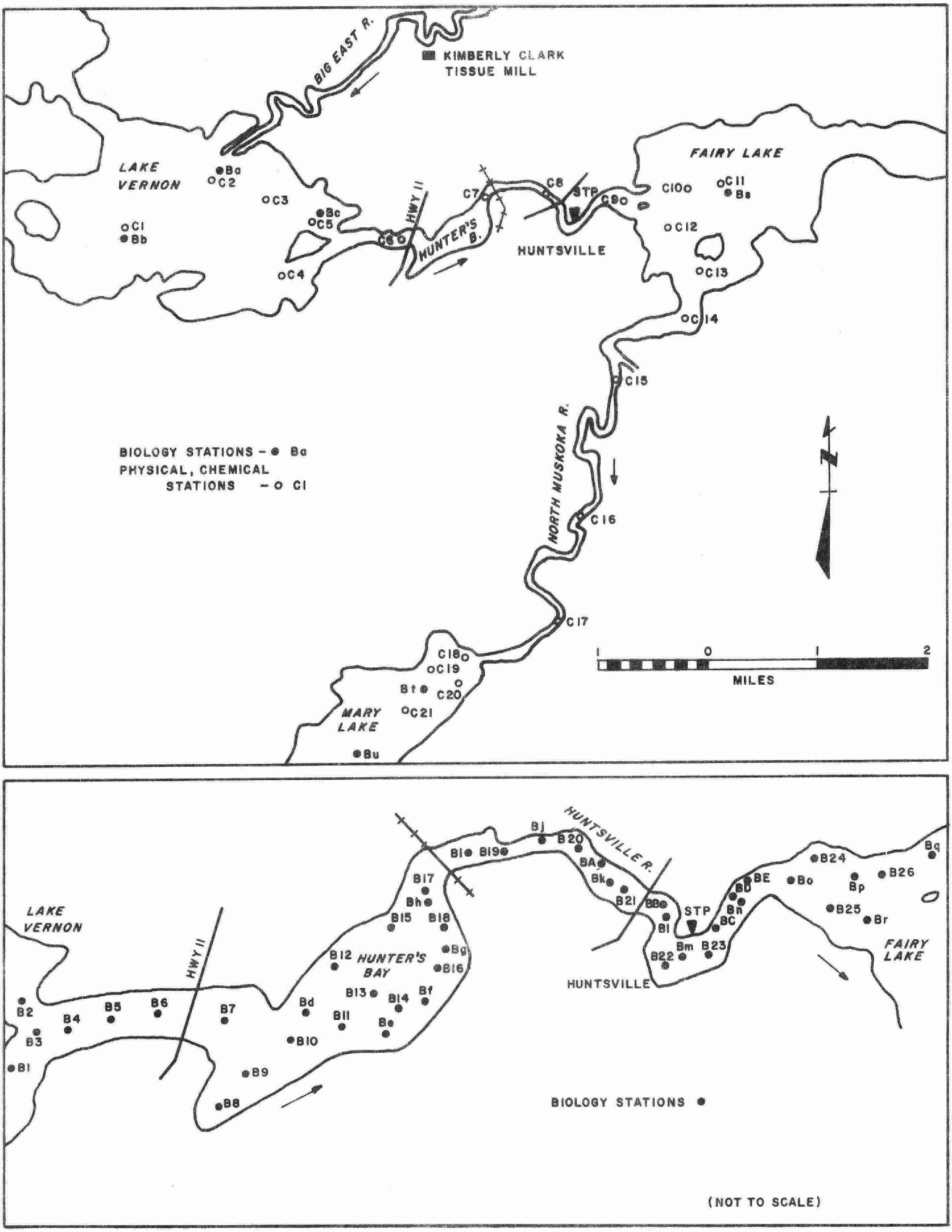


Fig. 1 Study area showing sampling locations

Vertical temperature profiles in the three lakes (Vernon, Fairy, Mary) were obtained by using either a telethermometer or a combined telethermometer-dissolved oxygen meter. When the latter was used, both temperature and dissolved oxygen were recorded. Otherwise, dissolved oxygen in surface and bottom water was measured using a dry chemical field kit from the HACH Chemical Company. At stations where the bottom water was not evaluated, surface measurements of temperature and dissolved oxygen were recorded from a temperature-oxygen meter.

Water clarity was measured either by using a secchi disc (8 inch diameter with alternate black and white quadrants), or by having water samples analysed at the Rexdale laboratory for Jackson Turbidity Units (J.T.U.'s).

Carbon dioxide was estimated in the field using a field kit from the HACH Chemical Company. Alkalinity and pH were measured either in the field using HACH kits, or samples were returned to the Rexdale laboratory for analyses.

All the other physical-chemical parameters illustrated in the Appendices were measured at the Ministry of Environment's Rexdale laboratory using standard procedures (Standard Methods, 13th Edition).

B) Biological

The biological work was restricted to a) chlorophyll analyses and b) an investigation of the bottom fauna.

Samples for chlorophyll analyses, which reflect the standing crop of algae present, were collected on four dates in 1971 in each of the three lakes (one station per lake). Samples were collected by lowering an uncapped glass bottle (0.9 l) to a depth corresponding to two times the secchi disc

value (this approximates the euphotic zone) and then raising the bottle at a rate which caused it to fill just as it surfaced. The sample was then preserved with magnesium carbonate. At the laboratory, one-liter samples were filtered through a 1.2 u membrane filter which was then placed in 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mu using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll 'a' were calculated using the equation given by Richards and Thompson (1952).

The bottom fauna were sampled using three techniques. In 1970, 21 locations (Ba-Bu, see Figure 1) were sampled using an Eckman dredge (520 cm^2), or a Ponar dredge (850 cm^2), depending on the physical characteristics of the substrate. In 1971, a total of 26 stations were sampled (B1-B26), using a Ponar dredge. In addition, five locations (BA-BE) were sampled using "artificial substrates".

Sediment from the dredges was placed in a "pail screen" and organisms were separated from the sediment and detritus by passing water through the brass screen (0.65 mm. aperture).

The "artificial substrates" were wire cages (15 cm x 20 cm x 20 cm) filled with 6.4-cm-crushed limestone. The five substrates were placed on the north side of the River in May of 1971. At monthly intervals (June, July, August), divers recovered the substrates by carefully rolling each one into the pail screen and retrieving it in such a way that any organisms washed off the substrate would be retained by the screen. Invertebrates were washed from the rocks using a toothbrush and were placed in 70-95% ethanol and returned to the Rexdale laboratory for enumeration and identification.

DISCUSSION OF RESULTS

A. Lake Vernon, Fairy and Mary Lakes

a) Basic Water Quality Characteristics:

Appendices I and II provide a tabulation of the physical-chemical data collected during 1970 and 1971. The three lakes (Vernon, Fairy, Mary) were found to be practically identical in physical-chemical characteristics. All three are characterized by soft water (15 mg/l hardness as $CaCO_3$) with low alkalinity (about 7 mg/l as $CaCO_3$), low conductance (conductivity of 40 umhos/cm) and low solids (30-40 mg/l total solids). Figure 2 provides some physical-chemical comparisons between these three lakes and other well-known lakes in Ontario.

The lakes are essentially "brown-water lakes". Color values were moderately high, ranging from 20 to 30 color units. The brownish coloration is typical of many lakes in the Pre-Cambrian area and is a result of dissolved organic compounds (e.g. tannic acid, lignins) which have leached into the water from decaying organic materials (e.g. leaves). Unlike the characteristics of hardness, alkalinity, conductance and solids, which make the water ideal for most recreational and municipal uses, the degree of color does lessen the value of these lakes as a public-water supply. The desirable criteria for coloration of water for public water supplies is less than 5 color units ("Guidelines and Criteria for Water Quality Management in Ontario"), although values greatly above 5 do not constitute health problems.

Although the water is moderately colored, water clarity is reasonably good. Secchi disc values (mean values) ranged from 3.0 meters to 4.6 meters and turbidity measurements ranged from 4 Jackson Turbidity Units to 8 J.T.U.'s.

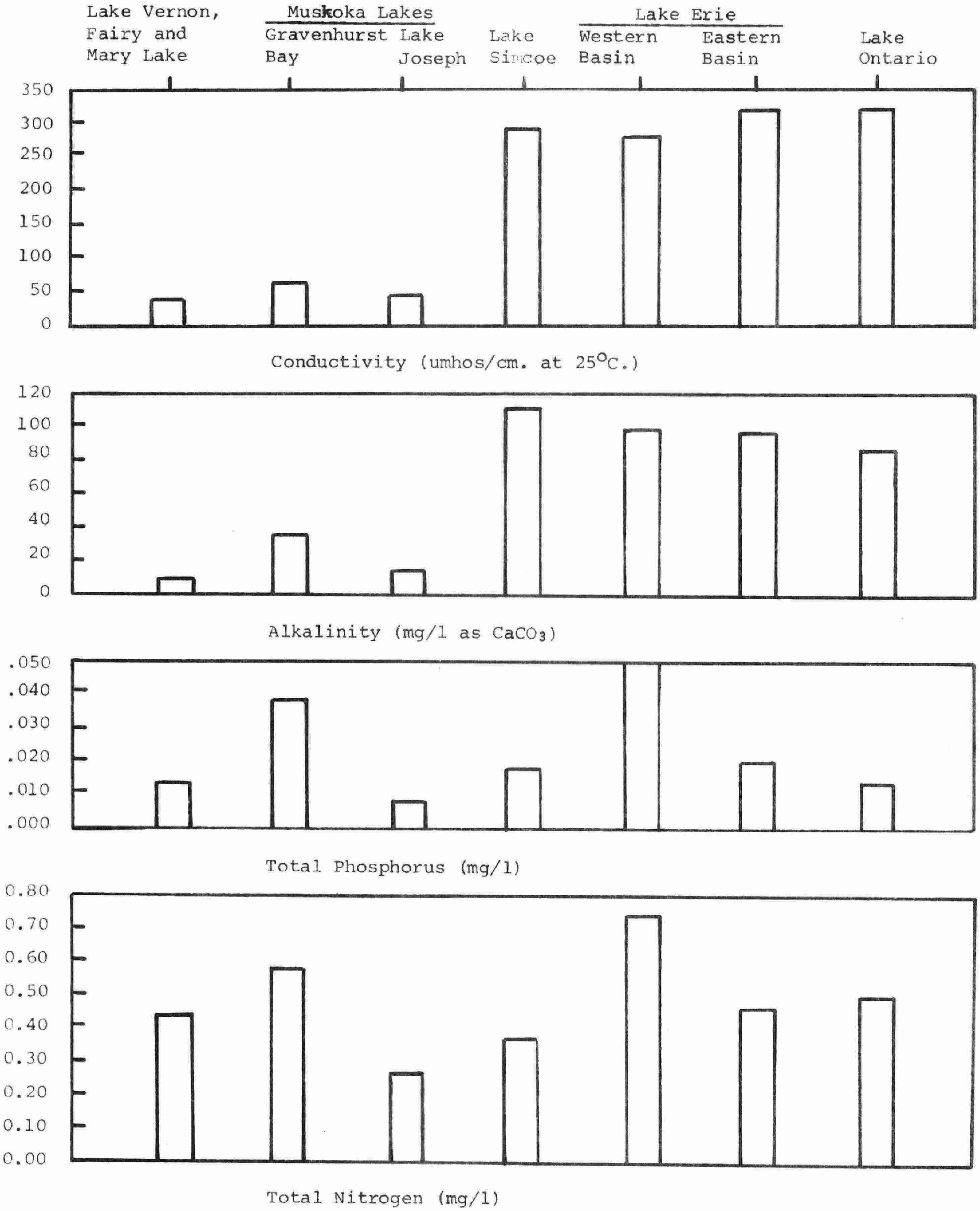


Figure: 2 A comparison of some physical-chemical characteristics of lakes in the study area, with other lakes in Ontario.

Both suspended materials (e.g. plankton) and dissolved organics (e.g. tannic acid) reduce water clarity, although it is expected that dissolved organics constitute a more significant factor in these unproductive lakes.

The pH of Lakes Vernon, Fairy and Mary, not unlike most lakes in the Pre-Cambrian area, is slightly acidic (mean values 5.9 to 7.2). The waters have a very low mineral content due to the geology of the area (primarily granite bedrock) and are therefore poorly buffered. Carbon dioxide, even though the concentrations are low (<5 mg/l), is therefore effective in maintaining acidic conditions.

b) Enrichment Status:

Concentrations of phosphorus, nitrogen, carbon and chlorophyll are commonly used to assess the enrichment or "trophic" status of a lake. The three lakes under consideration contained fairly low concentrations of the three major plant nutrients(i.e. N, P, C), as well as low concentrations of chlorophyll 'a' which is the plant pigment responsible for photosynthesis.

Figure 2 illustrates comparisons of phosphorus and nitrogen in Lakes Vernon, Fairy and Mary, with concentrations found in some other Ontario lakes. It is interesting to note that while the three lakes can be classed as nutrient-poor or oligotrophic, levels of phosphorus and nitrogen are considerably above the values found in the more oligotrophic parts of the Muskoka Lakes system (e.g. Lake Joseph). The mean total phosphorus value for the three lakes was 0.014 mg/l (surface water). The mean value for soluble phosphorus was 0.004 mg/l (surface water) indicating that most of the phosphorus was tied up in particulate form (e.g. plankton).

The mean total nitrogen value in surface water was 0.45 mg/l with slightly over half of the nitrogen in the organic kjeldahl form. Almost all the samples collected contained between 0.1 and 0.2 mg/l of nitrate nitrogen and it therefore appears that nitrogen is not acting as a limiting algal nutrient.

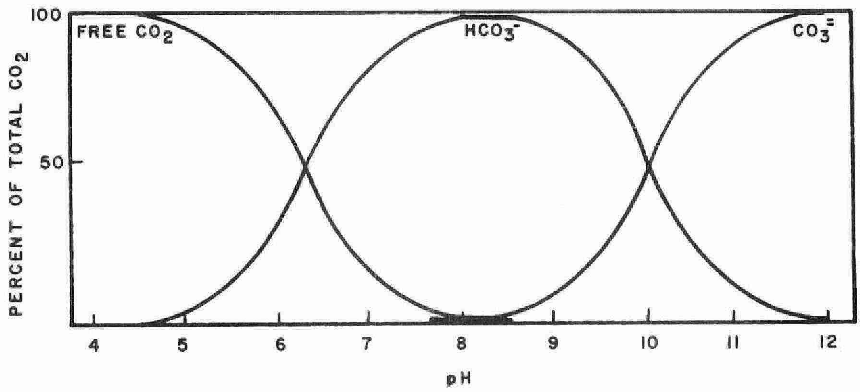
The mean value for total carbon was 8.5 mg/l. Average concentrations of inorganic carbon were 1.0 mg/l in all three lakes.

The ratios of phosphorus to nitrogen to carbon are as follows (averaging surface values for the three lakes):

Total P/Total N/Total C
1/32/610
Soluble P/Inorganic N/Inorganic C
1/50/250

While the ratios of these three important nutrients in the aquatic biota vary considerably, a fairly typical ratio for algae can be assumed to be 1/16/106. In Lakes Vernon, Fairy and Mary, the ratios in surface water are considerably different from this 'typical' ratio due to the larger amounts of carbon and nitrogen per unit of phosphorus. Even the ratio of inorganic nutrients (i.e. 1/50/250) would indicate that the supply of phosphorus for algal growth is more limiting than are nitrogen and carbon.

It is also of interest that most of the inorganic nitrogen is in the form of nitrate which can be readily used by algae. The inorganic carbon can be assumed to be present both in the form of carbon dioxide, and in the bicarbonate ion, with no carbon in the form of carbonate because of the relationship between pH and the carbon dioxide-bicarbonate-carbonate buffering system (illustrated below).



(Illustration from Emerson, R. and L. Green, 1938)

Carbon dioxide can be utilized by the algae either if the compound exists as free CO_2, or if it exists as HCO_3 - in the surrounding medium.

Therefore, considering the facts that 1) phosphorus concentrations in the three lakes are low and 2) the ratios of phosphorus to nitrogen and phosphorus to carbon are lower than the ratios observed in "typical" aquatic biota, it would appear that phosphorus is more limiting to algal growth than are nitrogen and carbon.

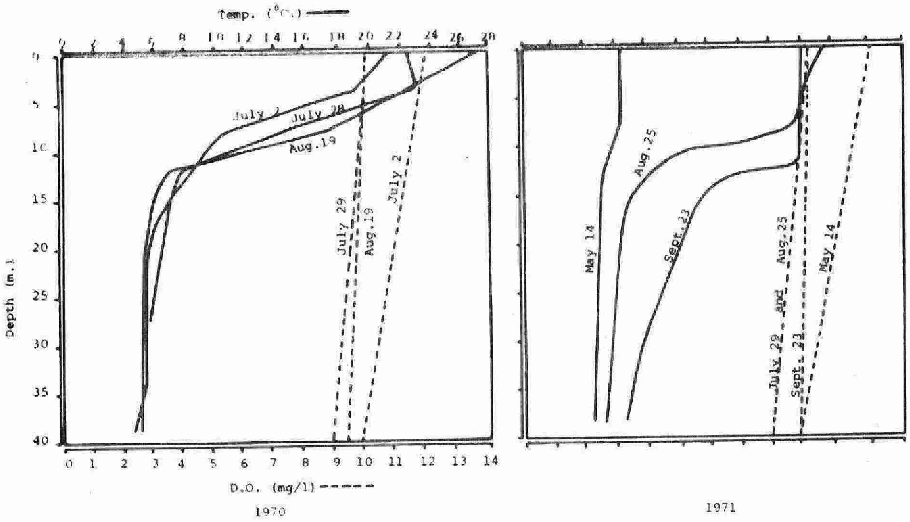
Chlorophyll 'a' values for the three lakes averaged below 5 mg/m^3. Concentrations ranged from 0.6 mg/m^3 on Sept. 23/1971 in Lake Vernon to 7.6 mg/m^3 on Aug. 25/1971 in Fairy Lake. Lake Vernon had the lowest average chlorophyll concentration (mean of 1.4 mg/m^3), while Fairy Lake had the highest (mean of 3.8 mg/m^3); these differences between the lakes may well reflect the lack of sampling frequency, although the possibility that the higher values in Fairy Lake reflects enrichment from Huntsville, must be kept in mind.

c) Stratification:

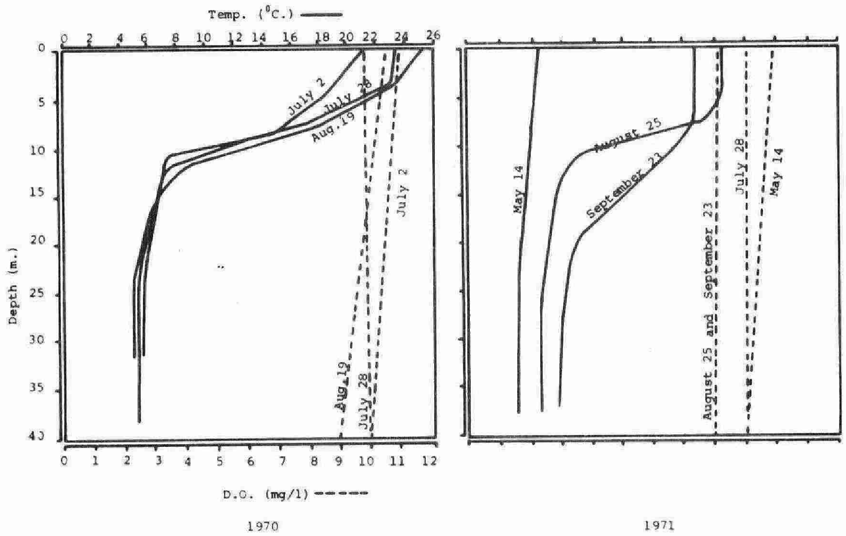
Thermal stratification of lakes during the ice-free period is frequently an important factor in governing limnological characteristics of the water. The degree and length of thermal stratification, the position of the thermocline and the ratios of hypolimnetic depth: epilimnetic depth, and hypolimnetic volume: epilimnetic volume, all influence lake limnology and lake ecology.

Figure 3 illustrates the vertical profiles of temperature and dissolved oxygen collected from the three lakes during 1970 and 1971 (Lake Vernon was sampled only in 1971). Temperature data revealed that during the summer months, all three lakes are characterized by pronounced thermal stratification. The metalimnion was normally at approximately the 10 meter depth and it increased in depth as the summer progressed. The hypolimnetic area experienced little warming as its temperature went from 4°C in winter and spring, to approximately 6°C just prior to fall turnover. This small increase illustrates that there is a minimum of vertical mixing and resulting heat transfer through the metalimnion.

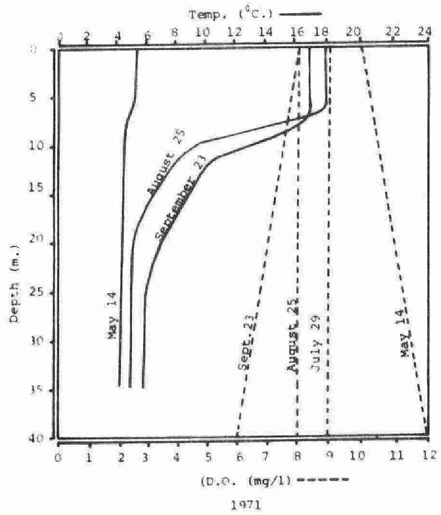
Profiles of dissolved oxygen, also illustrated in Figure 3, reveal similar concentrations throughout the water column during the summer stratification period. Concentrations were near saturation in most cases in both surface and bottom water. The lowest concentration (6 mg/l) was found in the bottom of Lake Vernon on Sept. 23, 1971. The orthograde profile of dissolved oxygen reflect the unproductive nature of these lakes, as well as the large depth and volume of the hypolimnetic zone.



Station C-11 Fairy Lake



Station C-21 Mary Lake



Station C-1 Lake Vernon

Fig. 3 Vertical profiles of temperature and dissolved oxygen in Lake Vernon, Fairy and Mary Lake, 1970 and 1971.

Appendix II illustrates that all of the parameters measured, with the obvious exception of temperature, showed very similar water quality conditions between the epilimnion and hypolimnion. While there was a slight decrease in pH in the bottom waters (<1 unit below surface values), and a slight increase in carbon dioxide, vertical stratification of the common parameters (e.g. B.O.D., alkalinity, conductivity, phosphorus, carbon) was practically non-existent. This lack of chemical stratification again reflects the oligotrophic nature of these lakes.

d) Bottom Fauna:

Invertebrate data collected from the three lakes is tabulated in Appendix III. The six sampling locations (3 on Vernon, 1 on Mary, 2 on Fairy) are illustrated in Figure 1.

The data obtained from the 30 dredge samples collected in 1970 (5 samples at each of the six lake locations) is not considered sufficiently representative to allow for a detailed discussion and interpretation. However, the following general comments are pertinent. Firstly, the basic community structure is fairly similar to that found throughout most parts of the Muskoka Lakes system in the 1969 survey carried out by the Ministry (report in preparation). The orders diptera and oligochaeta dominated the benthos in all three lakes, not unlike the typical situation for profundal areas of most oligotrophic lakes. Chironomids constituted the most abundant family of organisms, with tubificids rating second and culicidae (i.e. Chaoborus) third. Biting midges (i.e. Ceratopogonidae) and fingernail clams (Sphaeriidae) also constituted significant parts of the community.

Invertebrate densities varied considerably between sampling locations. In Lake Vernon, the population densities ranged from 276 organisms per m^2 at Bc, to 333 at Bb and 845 at Ba. Station Ba is located near the mouth of the East River (Figure 1) and the high density at this location probably is a result of organic deposition as the East River enters Lake Vernon. Densities at Bb and Bc are assumed to be representative of the profundal benthos of Lake Vernon and are similar to the densities found throughout most of the Muskoka Lakes system.

Station Bs in Fairy Lake supported a fairly high density of invertebrates (1035 per m^2) which would indicate that the deposition of organics to the sediment may be higher in this lake. While this possibility is supported by apparently higher chlorophyll concentrations in this lake (outlined previously), other parameters such as dissolved oxygen, phosphorus and nitrogen, indicate that all three lakes are practically identical in limnological characteristics. It is quite possible that the invertebrate fauna at **Bs** is atypical of the Lake.

The two stations in Mary Lake revealed densities of 242 and 673 per m^2 which again is similar to the densities found in the Muskoka Lakes.

B. <u>Huntsville and North Muskoka Rivers</u>

a) Physical-Chemical:

Data from the Huntsville River (stations C6-C9) and the North Muskoka River (C15-C18) are listed in Appendix II.

Most of the physical-chemical characteristics of these rivers are very similar to the characteristics of

the interconnecting lakes which have been discussed. Dissolved oxygen values were near saturation at all the river stations. Levels of B.O.D., C.O.D., pH, hardness, color, iron, solids and nitrogen were very similar from one station to the next as well as between the rivers and the three Lakes. Concentrations of specific ions (chloride, calcium, sulfate, sodium) were also very similar at all the river sampling locations.

Parameters that did show some differences between stations include water clarity (J.T.U.'s), conductivity and phosphorus. Appendix II illustrates that Jackson Turbidity Units varied considerably between stations, ranging from 1 at C18 to 11 at C7. These differences are basically unexplainable but may well be a result of non-representative samples and inaccuracies of the turbidity test. Conductivity indicated a slight difference between the two rivers; values in the Huntsville River ranged from 37 to 43 umhos/cm. Conductivity in the North Muskoka River was slightly higher (42 to 45 umhos/cm), no doubt reflecting the typical downstream increase in dissolved salts. It is also of interest to note that on the Huntsville River, the highest conductivity value (43 umhos/cm) was found at C9 which is just downstream from Huntsville and may be a result of the input of dissolved solids from the Town of Huntsville.

Concentrations of phosphorus in the two rivers were similar; however, at C9, both soluble and total phosphorus levels were found to be elevated above the values at other stations. This elevation is believed to be a result of the phosphorus-rich discharge from the Huntsville sewage treatment plant. This input, along with other nutrient sources (e.g. seepage from septic tanks, leeching from lake sediments) can lead to a slow depreciation of water quality. It is therefore important that any obvious nutrient sources be minimized; the recently installed phosphorus-removal facility at the sewage treatment plant at Huntsville is obviously an important step in this regard.

b) Biological:

The 60 macroinvertebrate samples collected from the Huntsville River (including Hunters Bay) during 1970 and 1971 revealed a fairly diverse community which changed little between the various sections of the River. Dominant groups of organisms included mayflies, caddisflies, diptera larvae, clams, snails and worms. The numbers and types of macroinvertebrates collected at each sampling location are illustrated in Appendices III and IV.

In analyzing and interpreting the bottom fauna data, particular attention was paid to Hunters Bay and to the area near the effluent of the Sewage Treatment Plant. Preliminary sampling during 1970 revealed accumulations of wood chips throughout much of Hunters Bay as a result of the previous water transport of logs. In 1971, many invertebrate samples were therefore collected from this area in order to determine the effect of these wood particles on the structure of the macroinvertebrate community.

The large variability in bottom fauna between samples limited interpretations. However, Figure 4 illustrates general comparisons between various sections (I, II, III, IV) of the River. The density of organisms and the average number of taxa per sample are illustrated on bar graphs on the bottom of the Figure.

The average number of taxa per dredge sample varied from 4.4 in section II, to 5.9 in section IV. While the lowest diversity in section II (Hunters Bay) may be a result of wood chips, it is more likely a result of the deeper water along with natural variability. It is of interest to note that the diversity of taxa upstream from the sewage treatment plant (5.8 per sample) was practically identical to that found downstream (5.9 per sample).

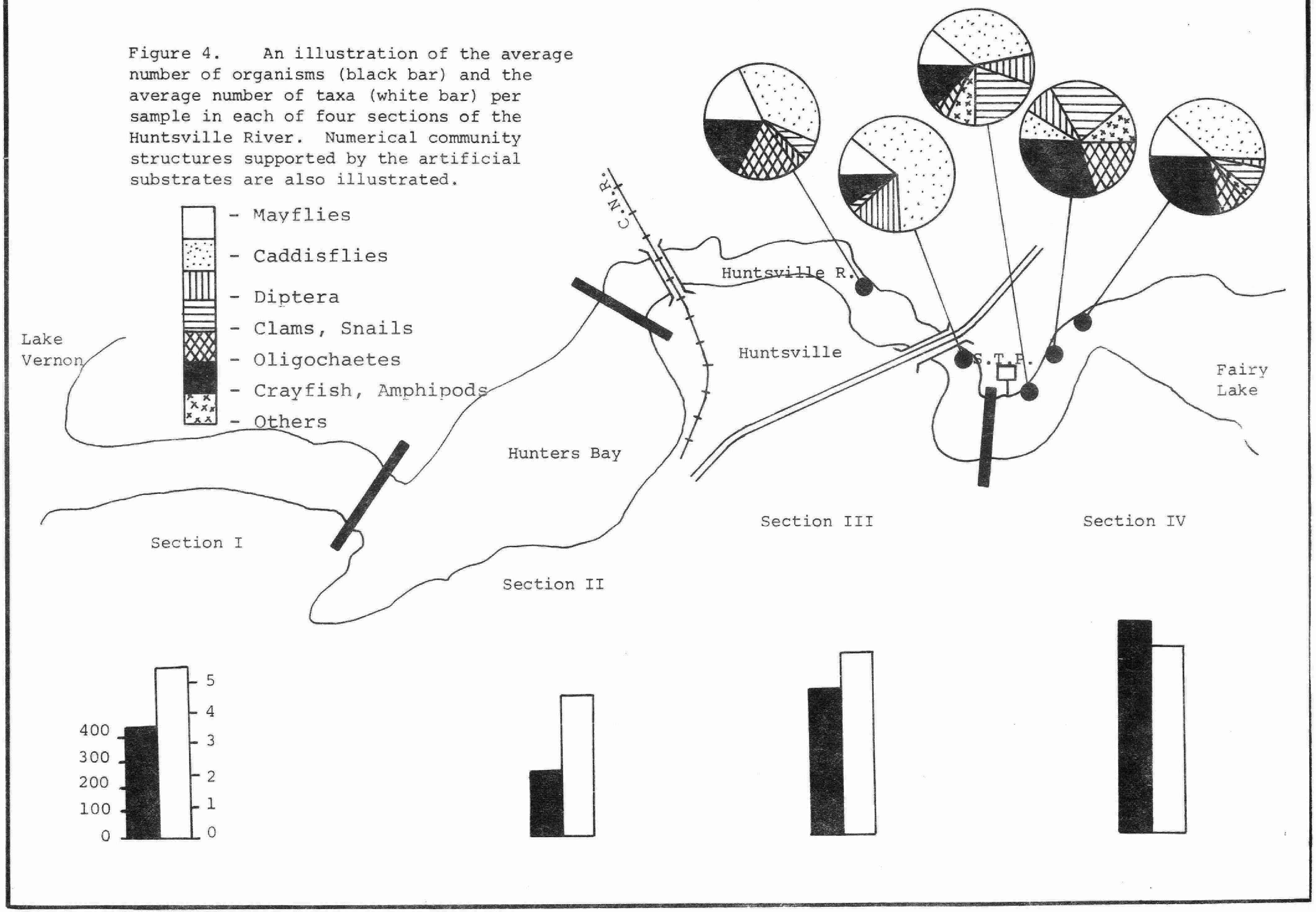


Figure 4. An illustration of the average number of organisms (black bar) and the average number of taxa (white bar) per sample in each of four sections of the Huntsville River. Numerical community structures supported by the artificial substrates are also illustrated.

The density of invertebrates varied considerably between the four areas (255 per m^2 in section II to 850 per m^2 in section IV). However, these changes are expected to be a result of different physical conditions between areas (e.g. depth, current) rather than being a result of differences in water quality.

Figure 4 also illustrates the community composition found on the artificial substrates. The substrates were used during 1971 specifically to evaluate the effects of the discharge from the sewage treatment plant on the river. They were all placed on the north side of the river upstream and downstream from the effluent. Because the substrates eliminate many of the physical variables encountered in dredging, the substrate data is probably the most useful in assessing the ecological effect of the treated municipal sewage.

Data from these substrates indicated that the community structure downstream from the municipal discharge (BC,BD,BE) was very similar to that found upstream at BA and BB (Figure 4). All five substrates supported a well-balanced community containing a variety of "pollution-sensitive" organisms (e.g. mayflies, caddisflies).

c) Visual Observations:

Wood particles were observed in most of the dredge samples collected from Hunters Bay. Some samples collected near Weldwood of Canada Limited appeared to contain a greater volume of wood particles than natural sediment. In the north-east corner of Hunters Bay, large piles of wood chips were predominant along the shoreline and were continually being eroded by wave action.

Visual observations were also recorded on the presence and extent of periphyton growth on the five artificial substrates. In June, the substrates at stations BA, BB, BD and BE were practically free of growth. At station BC, however, located about 70 meters downstream from the S.T.P. effluent, the substrate did support some periphyton. In the July sampling, BA and BB again were practically free of periphyton, BC was quite heavily coated, and BD and BE supported some growth. In August, field notes on periphyton growths were not maintained. It is assumed that the higher concentrations of nutrients (particularly P) downstream from the Sewage Treatment Plant promoted the increased growth at BC and to a lesser degree at BD and BE.

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APPENDIX I. Physical-chemical data collected from Fairy and Mary Lakes during 1970. Data represents average values. ('a' = surface water, 'b' = bottom water)

Station	Temp. °C	Clarity Turbidity J.T.U.	D.O. mg/l	B.O.D. mg/l	C.O.D. mg/l	pH	Alkalinity mg/l as $CaCO_3$	Hardness mg/l as $CaCO_3$
C11a	22.8	--	10.6	--	--	7.2	7	--
b (40m)	4.2	--	9.5	--	--	5.9	6	--
C21a	22.9	--	10.1	--	--	7.0	6	--
b (40m)	4.5	--	9.6	--	--	6.0	7	--

Station	Conductivity umhos/cm	Solids mg/l		Phosphorus mg/l		Nitrogen mg/l			
		Susp.	Diss.	Sol.	Tot.	NO_2	NO_3	Kjeldahl	NH_3
C11a	42	--	--	--	.015	.003	.16	.35	.017
b (40m)	41	--	--	--	.020	.007	.22	.275	.012
C21a	40	--	--	--	.015	.006	.15	.45	.02
b (40m)	42	--	--	--	.016	.004	.22	.36	.015

APPENDIX II. Physical-Chemical data collected from the Lake Vernon to Mary Lake waterway during 1971. Data represents average values. (Appendix II continued on succeeding pages).

	Temp. °C	Water Secchi	Clarity Turbidity	D.O. mg/l	B.O.D. mg/l	C.O.D. mg/l	pH	Alkalinity mg/l	CO_2 mg/l	Hardness mg/l as $CACO_3$	Conductivity	Color Units	Iron mg/l as Fe
C1a	15.3	4.6	4	8.8	.7	--	6.7	6.3	< 5	14	37	30	.26
C1b (30m)	5.1	--	6	9.0	.7	--	6.1	5.6	< 5	15	37	30	.45
C2	19.5	--	6	8.1	.7	<30	6.8	--	--	14	38	25	.23
C3a	19.3	--	5	7.7	.6	--	6.8	--	--	14	38	30	.25
C3b (16m)	6.4	--	7	9.8	.9	--	6.2	--	--	13	37	25	.33
C4	20.0	--	4	7.7	.7	<30	6.8	--	--	14	38	30	.24
C5	19.6	--	6	8.0	.9	<30	6.7	--	--	14	37	25	.28
C6	19.8	--	6	7.8	.6	<30	6.7	--	--	14	38	30	.26
C7	20.4	--	11	7.5	.6	<30	6.4	--	--	13	38	30	.30
C8	20.1	--	6	7.7	.7	<30	6.6	--	--	14	40	25	.36
C9	19.4	--	6	7.5	.9	--	6.5	--	--	--	43	30	.30
C10	19.6	--	6	9.6	.5	--	--	--	--	16	41	30	.15

APPENDIX II continued

	Solids mg/l		Phosphorus mg/l		Nitrogen mg/l				Chloride mg/l	Calcium mg/l	Sulfate mg/l	Sodium mg/l	Potassium mg/l
	Tot.	Diss.	Tot.	Sol.	NO_2	NO_3	NH_3	kjeld					
C1a	--	--	.013	.004	.004	.19	.03	.25	37	4	6	1.0	.58
C1b (30m)	--	--	.015	.003	.004	.33	.013	.25	--	4	--	--	.40
C2	50	--	.013	.002	.003	.16	.02	.26	2	4	5	1.0	.60
C3a	--	--	.013	.003	.003	.15	.02	.25	2	4	5	1.0	.50
C3b (16m)	--	--	.015	<.001	.003	.28	.02	.25	2	4	<5	1.0	.50
C4	40	--	.021	.003	.004	.15	.02	.24	2	4	5	1.0	.23
C5	30	--	.011	.002	.003	.15	.02	.25	2	4	5	1.0	.50
C6	45	--	.019	.002	.003	.14	.01	.26	2	4	5	1.0	1
C7	50	--	.016	.002	.004	.13	.01	.21	2	4	8	--	--
C8	45	--	.019	.002	.008	.14	.05	.30	2	4	11	--	--
C9	30	25	.034	.016	.004	.14	.07	.29	--	--	8	--	--
C10	35	30	.010	.025	.003	.16	.02	.19	--	4	5	--	--

APPENDIX II continued

	Magnesium mg/l	Carbon mg/l Inorgan.	Organ.
C1a	<1	1.0	6.5
C1b (30m)	<1	1.0	7.5
C2	<1	--	--
C3a	<1	--	--
C3b (16m)	1.0	--	--
C4	<1	--	--
C5	.9	--	--
C6	<1	--	--
C7	<1	--	--
C8	<1	--	--
C9	--	--	--
C10	1	--	--

APPENDIX II continued

Station	Temp. °C	Water Secchi (m)	Clarity Turbid-ity J.T.U.	D.O. mg/l	B.O.D. mg/l	C.O.D. mg/l	pH	Alkalinity mg/l as $CACO_3$	CO_2 mg/l	Hardness mg/l as $CACO_3$
C11a	14.7	3.0	6	9.0	.7	--	6.6	7.6	<5	15
C11b (40m)	5.6	--	4	8.4	.7	--	6.2	7.0	<5	16
C12	19.4	--	6	6.6	.7	--	--	--	--	13
C13	19.3	--	4	6.5	.7	--	--	--	--	14
C14	19.3	--	4	6.5	.6	--	--	--	--	14
C15	19.1	--	6	7.0	.5	--	--	--	--	15
C16	19.5	--	3	9.1	.5	--	--	--	--	15
C17	19.4	--	3	6.6	.7	--	--	--	--	15
C18	19.5	--	1	6.5	.6	--	--	--	--	15
C19	19.5	--	4	7.4	.4	--	--	--	--	16
C20	19.5	--	8	7.3	.6	--	--	--	--	16
C21a(1m)	14.6	3.6	6	8.3	.4	--	6.7	8.0	< 5	16
C21b(40m)	5.0	--	8	8.5	.4	--	6.5	6.3	< 5	16

APPENDIX II continued

Station	Conductivity umhos/cm	Color Units	Iron mg/l as Fe	Carbon mg/l Organ.	Carbon mg/l Inorg.	Solids mg/l Tot.	Solids mg/l Diss.	Phosphorus mg/l Tot.	Phosphorus mg/l Sol.
C11a	40	20	.15	6.5	1.0	30	25	.014	.003
C11b (40m)	41	30	.28	7.5	1.0	25	20	.013	.002
C12	41	20	.18	--	--	30	25	.015	.003
C13	40	10	.15	--	--	40	35	.014	.001
C14	41	15	.15	--	--	40	35	.012	.002
C15	42	20	.42	--	--	50	45	.011	.001
C16	42	30	.20	--	--	35	30	.017	.003
C17	43	20	.25	--	--	30	25	.014	.004
C18	45	20	.18	--	--	30	25	.016	.002
C19	42	30	.20	--	--	--	--	.010	.002
C20	42	30	.15	--	--	--	--	.012	.002
C21a (1m)	41	30	.20	9.5	1.0	--	--	.016	.006
C21b (40m)	41	30	.23	11.5	1.0	40	--	.012	.002

APPENDIX II continued

Station	Nitrogen NO_2	NO_3	NH_3	kjeld	Chloride mg/l	Calcium mg/l	Sulfate mg/l	Potassium mg/l	Magnes-ium mg/l
C11a	.004	.16	.02	.26	--	4	8	--	1
C11b (40m)	.004	.32	.02	.23	--	4	5	--	1
C12	.004	.15	.01	.25	--	4	8	--	<1
C13	.003	.15	.03	.24	--	4	--	--	<1
C14	.004	.15	.02	.22	--	4	--	--	<1
C15	.004	.14	.02	.20	--	5	8	--	<1
C16	.005	.14	.04	.25	--	5	8	--	<1
C17	.003	.16	.021	.22	--	5	8	--	<1
C18	.005	.13	.01	.23	--	5	8	--	<1
C19	.003	.16	.01	.22	--	4	--	--	1
C20	.003	.17	.01	.32	--	4	--	--	1
C21a (1m)	.004	.19	.02	.26	--	4	--	--	1
C21b (40m)	.004	.28	.01	.20	--	4	8	--	1

APPENDIX III. A tabulation of the types and numbers of macroinvertebrates obtained from dredge samples from the Lake Vernon to Mary Lake waterway during 1970.
(APPENDIX continued on following page).

Organism	Numbers of Organisms Per M^2 At Each Station										
	Ba	Bb	Bc	Bd	Bs	Bt	Bu	Be	Bf	Bg	Bh
Mayfly - Ephemeridae	11								15	15	
Caenidae	4										
Caddisfly - Leptoceridae	8										
Psychomyiidae											
Diptera - Chironomidae	650	198	200	200	720	172	290	465	150	180	120
Ceratopogonidae	57	4		23		4	49		45	45	30
Culicidae	4	114	30	34	80	27	34				
Beetle - Unidentified	8										
Clam - Sphaeriidae			38	11	8	8	4	150		15	30
Snail - Planorbidae				4							
Viviparidae								15	60	15	
Bulimidae				4				30	30		
Scud - Talitridae	4					4					
Worm - Tubificidae	76	19	8	69	227	23	296	120		30	
Leech - Unidentified	8			4							
Mite - Unidentified	15			4		4			15		
TOTAL # ORGANISMS	845	333	276	343	1035	242	673	780	315	300	180
TOTAL # TAXA	11	4	4	9	4	7	5	5	5	6	3

APPENDIX III - continued

Organism	Bi	Bj	Bk	Bl	Bm	Bn	Bo	Bp	Bq	Br
	Numbers of Organisms Per M^2 At Each Station									
Mayfly - Ephemeridae		30	15	15		30				
Caenidae										
Caddisfly - Leptoceridae						15	15		15	
Psychomyiidae			15					30	15	
Diptera - Chironomidae	15	15	60	90	90	315	150	45	300	75
Ceratopogonidae	15	195	90	100	15	300	60	45	30	60
Culicidae					15					
Beetle - Unidentified										
Clam - Sphaeriidae		60		15	60	60	75		45	30
Snail - Planorbidae										
Viviparidae			45							
Bulimidae				75	30	90	90	15	100	
Scud - Talitridae									30	
Worm - Tubificidae	45	60	105	15	540	345	100	570		405
Leech - Unidentified	15						15			
Mite - Unidentified		30		15		15				15
TOTAL # ORGANISMS	90	390	330	325	750	1170	505	705	535	585
TOTAL # TAXA	4	6	6	7	6	8	7	5	7	5

APPENDIX IV. A tabulation of the types and numbers of macroinvertebrates obtained from dredge samples from the Huntsville River during 1971.
(APPENDIX continued on following page).

Organism	Numbers of Organisms Per M^2 At Each Station													
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14
Mayfly - Ephemeridae	120	60	120	195	45	90	90	30	60	15		15		15
Caddisfly - Limnephilidae														
Leptoceridae		15												
Psychomyiidae			30			45			15					
Diptera - Chironomidae	135	720	585	135	30	30	30	525	150	30	180	120	75	75
Ceratopogonidae	15	30	150	15	15	30	30		15	45	45			
Culicidae														
Clam - Unionidae	15	15	45			15								
Sphaeriidae			15					180	15		15			
Snail - Bulimidae			45		15		15	15						
Viviparidae														
Unidentified														15
Isopod - Asellidae														
Amphipod - Talitridae														15
Oligochaete - Tubificidae			30										105	
Nevroptera - Sialidae	30	15		15				15	15					
Mite - Acari			15					45				15		
Leech - Unidentified		30												
TOTAL # ORGANISMS	315	885	1035	360	105	210	165	810	120	90	240	150	180	120
TOTAL # TAXA	5	7	9	4	4	5	4	6	6	3	3	3	2	4

APPENDIX IV - Continued

	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26
Mayfly - Ephemeridae	195		15		30			15				
Caddisfly - Limnephilidae									15			
Leptoceridae												
Psychomyiidae			15		75	15				75		
Diptera - Chironomidae	75	570	330	540	435	15	60	75	1000	225	135	105
Ceratopogonidae	30		15	15	195		105		30	45		
Culicidae			15						15	15	15	30
Clam - Unionidae												
Sphaeriidae		45		105	30			15	105			
Snail - Bulimidae		90		240	15	15		105	210	30		
Viviparidae		165		75	15			15				
Unidentified						15						
Isopod - Asellidae												
Amphipod - Talitridae								15		30		
Oligochaete - Tubificidae	0	0	30	105	30	0	2000	75	0	135	1700	75
Neuroptera - Sialidae	30		15									
Mite - Acari		45	15		15			15	60			
Leech - Unidentified									30			
TOTAL # ORGANISMS	330	915	435	1095	840	60	2165	260	1465	555	1910	210
TOTAL # TAXA	4	5	7	6	8	4	3	8	8	7	3	3

APPENDIX V. Total numbers of organisms collected from each of the five artificial substrates on the Huntsville River during 1971. Each substrate was sampled three times (June, July, August).

Organism		Station				
		BA	BB	BC	BD	BE
Mayfly	Heptageniidae	24	17	34	1	16
	Leptophlebiidae	1	--	--	--	--
	Ephemerellidae	--	--	5	--	--
	Ephemeridae	2	--	--	--	--
	Caenidae	--	--	--	--	2
	Unidentified	--	--	1	--	--
Caddisfly	Psychomyiidae	57	109	137	10	63
	Limnephilidae	--	--	2	--	--
	Leptoceridae	2	--	--	1	--
	Hydroptilidae	--	--	--	1	6
	Unidentified	--	--	1	1	1
Dragonfly	Libellulidae	--	1	1	--	--
	Aeshnidae	--	--	--	3	--
	Gomphidae	--	--	--	--	1
	Corduliidae	--	--	--	1	--
Damselfly	Coenagriidae	--	--	4	2	--
	Agriidae	1	--	--	--	3
Diptera	Chironomidae	6	26	30	13	3
	Ceratopogonidae	1	--	--	--	--
	Empididae	--	--	1	--	--
Beetle	Dytiscidae	3	--	--	--	--
Crayfish	Astacidae	12	7	8	15	4
Clam	Sphaeriidae	4	1	--	4	--

APPENDIX V cont'd:

Organism		Station BA	BB	BC	BD	BE
Snail	Bulimidae	1	3	76	40	13
	Viviparidae	4	--	--	2	1
	Physidae	--	--	--	1	--
Isopod	Unidentified	--	1	--	28	--
Amphipod	Talitridae	--	1	34	14	5
Oligochaete	Tubificidae	28	--	20	27	14
Neuroptera	Sialidae	4	--	--	--	--
Flatworm	Planaria	1	1	30	1	10
Leech	Unidentified	--	2	1	5	--
Mite	Acari	2	1	3	3	1
TOTAL # ORGANISMS		153	170	388	173	143
TOTAL # TAXA		17	12	17	19	14